Table 7. Summary of electric costs and for drip and seepage irrigated tomatoes, Southwest Florida, Spring crop of 1987.

Item	Drip	Seep	Added[zyx] cost
	---------- $/acre ----------		
Variable costs:			
Electric energy	8.50	48.50	–40.00

[z]No machinery variable and fixed cost were considered since they are similar in both alternatives.
[y]Management and labor cost differences are not quantified.
[x]Based on a seasonal pumping requirements of 77 inches for seepage irrigation and 7.5 inches for drip irrigation.

the average for the two seasons of the observed water requirements for the two systems. This resulted in savings of $40 per acre in energy consumption due to reduced pumping requirements for the drip irrigated field (see Table 7). Therefore, lower pumping costs covered some of the additional fixed and variable costs of the drip irrigation system. The increase in total irrigation cost (excluding labor) was $136 per acre for the micro irrigation system. The high level of management required with drip irrigation may have economic significance.

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SILVER-LEAF OF SQUASH IN SOUTH FLORIDA

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Abstract. **A previously unrecognized disorder of squash (*Cucurbita pepo* L.) in Florida appeared in Palm Beach County during Sept. 1987. Mild symptoms included silvering along the main and secondary veins of the upper leaf surface resulting in an etched appearance. Severe foliar symptoms included complete silvering of the upper leaf surface. The lower leaf surface appeared normal. Additional symptoms include blanching of flowers and fruit of green cultivars (acorn and zucchini) and a scalding of the upper fruit surface of yellow cultivars. The most serious outbreaks have been in southern Palm Beach and northern Broward Counties. The condition has also been observed in Collier, Dade, DeSoto, Hendry, Monroe, and St. Lucie Counties. The condition developed within 24 hours in most fields indicating an episodic nature of the symptom development. Plants appeared to be more susceptible when they were growing luxuriantly and when they were under moisture stress.**

The first observation of leaf silvering in a commercial squash planting in Florida was made during late Sept. 1987 in Palm Beach County. The squash was *Cucurbita pepo* L., cv. Multipik. The squash plants were initiating flowers and growing very luxuriantly 1 week prior to the expression of leaf silvering symptoms. There were no immidiate indications of any physiological disorder, insects, or diseases in the planting. Within a week after flower initiation, the grower indicated that the upper surface of leaves turned a silvery color. Nearly every upper leaf surface had a silvery color with an exception being where one leaf had overlaid another. The lower leaves had the silvering symptom only where the upper leaves were not overlapping each other. This pattern of injury first suggested the possibility of spray injury. The planting had been sprayed recently with a boron solution (1 lb. Solubor per 100 gal of water). The grower disagreed with the diagnosis of boron injury since the concentration of Solubor used had no adverse effects on many previously grown squash plants. Also, the pattern of silvering was too uniform within the field to be attributed to a toxic spray application since a uniform spray coverage with one application could not have been obtained. Two days after the initial leaf silvering symptoms, the grower reported that several volunteer squash plants in another area of the farm which had not been sprayed with any chemical also had severe leaf-silvering symptoms.

During the next 2 months, observations of leaf-silvering were made on commercial squash plantings in Palm Beach and Broward Counties. Commercial squash fields

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Fig. 1. Symptoms of silver-leaf on foliage, flowers and fruits of squash. A) Severe symptom on upper leaf surface of yellow squash, B) mild etching symptom on upper leaf of yellow squash, C) Silvering on zucchini blossoms, D) Fruit symptoms (glazing on upper surface) of yellow squash, E) Fruit symptom (failure to color properly) on zucchini squash, and F) Fruit symptoms (failure to color uniformly, both internally and externally) on acorn squash.

without the silver-leaf symptoms were not observed during Dec., 1987 in these 2 counties. Nearly every cultivar of *Cucurbita pepo* L. were grown commercially in the area. Zucchini, yellow straight neck, acorn, pumpkin squash, and hubbard (*Cucurbita maxima*) all had similar silver-leaf symptoms.

Symotomatology of silver-leaf—The most conspicuous symptom of silver-leaf was the development of a uniform silvery appearance on the upper leaf surface. The lower leaf surface was unaffected. The silvering initiated within the main and secondary veins located on the upper leaf resulting in an etched appearance to the upper leaf surface (Fig. 1B). These leaf symptoms are clearly distinct from the genetic silvering which was attributed to a single do-

minant gene (5, 7, 8). The genetic silvering symptoms initiate as patches in axils of leaf veins on only the upper leaf surface (4) and usually do not spread into the veins or cover the entire leaf surface. The silvery color was attributed to an increased air space between the palisade and epidermal leaf layer (6).

Blossoms of zucchini have been observed on which the margins of the flowers were frosted in appearance (Fig. 1C). Fruit symptoms on yellow squash consist of a glazed or hard appearance to the upper (exposed) surface of the fruit. There usually was a clear line of demarcation between the injured and uninjured areas of the fruit (Fig. 1D). On green squash cultivars, fruits fail to produce pigment resulting in chlorotic to pale green colored fruit as illustrated with zucchini squash (Fig. 1E). Acorn squash ripened non-uniformly, and had a mottled chlorotic green pattern on the fruit. Some acorn fruit were uniformly pale in color. The flesh of acorn squash was white instead of the normal creamy color (Fig. 1F).

Economic impact of silver-leaf—The most severe damage occurred in acorn squash. Harvesting did not occur in 3 commercial acorn squash plantings in Palm Beach County during the 1987-88 season. Damage to zucchini has been severe in a few instances with every fruit having some chlorotic mottling. A grower of mini-squash was on the verge of going out of business. Economic losses were attributed to a reduction in number of harvests, reduced fruit quality, or to complete loss of fruit yields.

Etiology of silver-leaf—The cause of silver-leaf is unknown. A disease similar to silver-leaf has been observed in Israel (2). They consider leaf silvering of *Cucurbita* a physiological disorder, and attributed an increase in severity of the disorder to low soil moisture (2). Our observations also indicate that plants under stress were more severely affected.

There are no reports that indicate that the silvering symptoms on squash plants are the result of a pathogen or insect. Researchers from the Tropical Research and Education Center (University of Florida), Homestead, FL. indicated that whiteflies may be involved. However, no consistent association with large populations of whiteflies have been observed in field conditions.

Observational evidence suggests that an environmental factor(s) may be involved with the development of leaf silvering in squash. Leaf silvering occurred within 24 hours and there was definite indication that episodes resulted with the symptom's development. Areas most seriously affected have been in southern Palm Beach County and northern Broward County. The expression of symptoms were more evident during the fall and spring months. In areas which were severely affected, shrubs or trees growing on the east side of fields protected squash plants to the west. In the case of trees (Australian pines up to 40 feet high), the protective effect was evident for 75 to 100 feet within the field. In the case of shrubs (10 to 15 feet high) the effect was apparent for only 2 to 3 rows into the field. Since the commercial squash fields were located west of an urbanized area, shrubs and trees may have interfered with air circulated from the urban area. Shrubs and trees were providing shade (protection from stress) to the squash and may have attributed to the lower concentration of plants affected by the disorder. If this were the case, however, one would expect the plants on the west side of the field to be more protected than those on the east side since maximum water stress occurs in the afternoon, and shaded plants at that time would be on the west side of the field.

Silvering of leaves has been reported as a symptom of ozone damage with a number of plant species. Air pollution researchers from several locations in the United States have stated that symptoms on squash have not been previously observed or that ozone damage can be implicated. However, these researchers have not exposed squash plants to ozone under controlled conditions. The symptoms which were anomalous for ozone injury was the "netting or etching" found in mild cases (Fig. 1B). Other than the report from Israel (3), observations of silver-leaf on squash have not been made.

The Florida Department of Environmental Regulation monitors air pollution including ozone in Florida. Ozone levels in the atmosphere were monitored continuously in 6 Florida counties including Palm Beach, Dade, and Broward. Levels of ozone reach unacceptable levels (EPA standards of 0.12 ppm) on an infrequent basis in each of these counties. Records are available for several years and examination of these records does not indicate that there was a marked increase in ozone during 1987. Therefore, ozone, per se, would not appear to be the primary cause of silver-leaf in squash. This does not suggest that ozone was not involved. Studies made with ozone in combination with SO_2 and NO_2 as air pollutants (1, 4) indicate that combinations of ozone with SO_2 and/or NO_2 were much more toxic to plants than ozone alone. In addition, exotic chemicals formed in photochemical smog can be severely damaging to plants in concentrations of a few parts per billion. One of these, peroxyacetile nitrate (PAN), can act synergistically with ozone (1). Other exotic chemicals are known to exist, even though their specific chemistry has not been elucidated (1). The monitoring of ambient air by the Florida Department of Environmental Regulation does not include testing for such exotic chemicals.

Direction of research efforts—Research priority should be placed on studying the etiology of silver-leaf in squash. Establishment of a cause and effect relationship with a pathogen, insect, chemical, or physiological disorder is of immediate importance in the development of effective control measures. Simultaneous epidemiological investigations would establish any patterns governing the spread of symptoms within a commercial field or geographical region. With these future research efforts, vital control measures can perhaps reduce or eliminate the severe economical impact attributed to silver-leaf on the squash growers.

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